CONVERGENCE OF INCOME ACROSS PENNSYLVANIA COUNTIES

David A. Latzko, Wilkes University
Department of Business and Economics, Wilkes-Barre, PA 18766

ABSTRACT

The neoclassical growth model implies that if two economies have the same preferences and technology, the poorer economy will tend to grow faster in per capita terms. The relatively homogenous counties of Pennsylvania provide an excellent test of the model's prediction of convergence in living standards. But, there is no evidence of either unconditional convergence of income among Pennsylvania counties or convergence conditional on investment and population growth rates. Convergence is detected when the rate of human capital accumulation is added to the model. The speed of convergence is about 1.3 percent a year.

INTRODUCTION

The neoclassical growth model predicts that, under certain conditions, poor regions will grow faster than rich regions so that living standards across all regions will eventually be the same, even though some regions may start out way behind. Dowrick and Nguyen (1989) and Mankiw, Romer, and Weil (1992) both found that there has been a significant tendency towards convergence of per capita income among OECD countries while Barro and Sala-i-Martin (1992; 1995) found evidence of convergence across U.S. states and across Japanese prefectures. However, there is little empirical evidence to support this sort of unconditional convergence among more heterogeneous groups of nations (Mankiw, Romer, and Weil 1992; Romer 1994). The neoclassical model predicts that regions will converge to different steady-states if they differ in characteristics such as savings rates, population growth rates, or access to technology. The evidence for this kind of conditional convergence is quite convincing. Mankiw, Romer, and Weil (1992) found strong evidence of convergence in their sample of 98 non-oil countries when savings and population growth rates are taken into account. The purpose of this paper is to examine whether income has converged across Pennsylvania counties in accordance with the prediction of the neoclassical growth model.

THE NEOCLASSICAL MODEL

Consider the Solow version of the neoclassical growth model in which the rates of saving, population growth, and technological progress are assumed to be exogenous. Assume a Cobb-Douglas production function, so that output at time t, Y_t, is given by

(1) $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$

with $0 < \alpha < 1$. A is the level of technology, K is capital, and L is labor. L and A are assumed to grow exogenously at rates n and g:

(2) $L_t = L_0 e^{nt}$

(3) $A_t = A_0 e^{gt}$.

The Solow model assumes that a constant fraction of income, s, is invested in capital goods. Let $k_t = K_t/L_t$ and $y = Y_t/L_t$. The production function can then be written as

(4) $y_t = A_0 e^{gt} k_t^{\alpha}$,

so that the growth of k is given by

(5) $\Delta k_t = s y_t - (n + g + \delta) k_t = s A_0 e^{gt} k_t^{\alpha} - (n + g + \delta) k_t$,

where δ is the rate of depreciation. Equation (5) implies that k converges to the steady-state value k^* defined by $\Delta k_t = 0$ or

(6) $s A_0 e^{gt} k^{*\alpha} = (n + g + \delta) k^*$.

Equation (6) can be solved for the steady-state capital-labor ratio

(7) $k^* = [s A_0 e^{gt} / (n + g + \delta)]^{1/(1-\alpha)}$.

Substituting equation (7) into the production function and taking logs yields the steady-state income per capita:

(8) $\log y_t = 1/(1-\alpha)(\log A_0 + gt) + \alpha/(1-\alpha) \log s - \alpha/(1-\alpha) \log (n + g + \delta)$.

g, the rate of technological improvement, reflects the advancement of knowledge and, along with the rate of depreciation, δ, is assumed to be constant across counties. The term A_0 in equation (8) reflects many factors other than technology such as resource endowments, all of which may differ across counties. So, let $1/(1-\alpha)\log A_0$ equal $a + \varepsilon$, where a is a constant and ε is a county-specific shock independent of s and n. Then,

(8) $\log y_t = a + \alpha/(1-\alpha) \log s - \alpha/(1-\alpha) \log (n + g + \delta) + \varepsilon.$

CONVERGENCE

The growth of the capital stock per worker is given by equation (5). Take the first-order Taylor expansion around the steady-state capital-labor ratio:

(10) $dk/dt = [s dy/dk^* - (n + g + \delta)](k - k^*).$

In the steady-state, s is equal to $(n + g + \delta)(k^*/y^*)$, where y^* is the steady-state income per capita given by equation (9). Substitute this into equation (10):

(11) $dk/dt = [(k^*/y^*)(dy/dk^*) - 1](n + g + \delta)(k - k^*).$

If capital earns its marginal product, then $(k^*/y^*)(dy/dk^*)$ equals α, capital's share of income. Then,

(12) $dk/dt = (\alpha - 1)(n + g + \delta)(k - k^*)$

Income converges to its steady-state level at the same rate as capital. So, if the actual level of income per capita at time t is y_t, then the speed is convergence is found by

(13) $d \log (y_t)/dt = \lambda (\log y^* - \log y_t),$

where $\lambda = (n + g + \delta)(1 - \alpha)$. Then,

(14) $\log y_t = (1 - e^{-\lambda t}) \log y^* + e^{-\lambda t} \log y_0,$

where y_0 is per capita income at some starting date. Subtracting $\log y_0$ from both sides and substituting for y^* yields the basic empirical specification

(15) $\log y_t - \log y_0 = (1 - e^{-\lambda t})(a + \alpha/(1-\alpha) \log s - \alpha/(1-\alpha) \log (n + g + \delta) + \varepsilon) - (1 - e^{-\lambda t}) \log y_0.$

Equation (15) says that the growth of income is a function of the determinants of the steady-state level of income and the initial level of income. The savings rate has a positive correlation with income growth while the rate of population growth and the initial level of income are negatively related to the rate of per capita income growth. A negative coefficient on the log of initial income per capita would be evidence of convergence of income per capita across Pennsylvania counties.

Data and sources

This paper tests for convergence of per capita income across Pennsylvania counties over the period 1969 to 1994. The analysis covers 66 of the 67 Pennsylvania counties. Wyoming County is excluded because data on new capital expenditures in this county are not available. Personal income and population for 1969 is from *Local Area Personal Income* while 1994 personal income and population for each county are taken from the U.S. Department of Commerce, Bureau of Economic Analysis Web page.[1] Use of personal income is problematic if people work in one county and live in another or if people tend to own capital in other counties because the personal income accounts reported by the BEA assign income to the county in which the owner of the inputs resides. Unfortunately, no measure analogous to Gross Domestic Product is available on a county basis. Fortunately, Barro and Sala-i-Martin (1992) show that at the state level at least the distinction between personal income and gross state product is unimportant in explaining economic growth.

The Census Bureau reports new capital expenditures by county in its *Census of Manufactures*. Manufacturers are asked to report their new expenditures for permanent additions and major alterations to manufacturing establishments, and machinery and equipment used for replacement and additions to plant capacity. The totals for new expenditures include expenditures leased from nonmanufacturing concerns through capital leases. New facilities owned by the federal government but operated under contract by private companies, and plant and equipment furnished to the manufacturer by communities and nonprofit organizations are excluded. Also excluded are expenditures for used plant and equipment, expenditures for land, and cost of maintenance and repairs charged as current operating expenses.

The fraction of income invested in new capital goods, s, is calculated for each county by averaging the available values of new capital expenditures divided by county personal income for the years 1972, 1982, and 1992. The 1972 and 1982 numbers are from the 1977 and 1988 editions of the Census Bureau's *County and City Data Book* while the 1992 value of new capital expenditures is from the *1992 Census of Manufactures*. No new capital expenditure data is available for Wyoming County. Finally, I assume that $g + \delta$ is equal to 0.05 to match the available data.[2]

Results

Figure 1 plots the average annual rate of per capita income growth over 1969-94 against the log of 1969 income per capita for all 67 Pennsylvania counties. Unconditional convergence implies a negative relationship between the rate of income growth and initial income, but the graph reveals no such obvious relationship.

I use OLS to more rigorously test the convergence predictions of the neoclassical model.[3] The first column of Table 1 reports on the estimation of

(16) $$\log y_{1994} - \log y_{1969} = \text{constant} + \log y_{1969}.$$

The coefficient on the log of initial per capita income is negative, but both the coefficient and the adjusted R^2 are essentially zero. There is no tendency for poor Pennsylvania counties to unconditionally grow faster on average than rich counties.[4] But, the neoclassical model does not imply unconditional convergence. Mankiw, Romer, and Weil (1992) argue that the model predicts conditional convergence, convergence after controlling for the determinants of the steady-state level of income. Incomes per capita converge holding all other variables constant. The second column of Table 1 adds the logs of *s*, the fraction of income invested in new capital goods, and $(n + g + \delta)$ to the right-hand side of equation (16). All the coefficients have the expected sign but are again not significantly different from zero. There is not yet evidence of convergence, unconditional or conditional, of incomes across Pennsylvania counties.

Adding human capital to the model

Mankiw, Romer, and Weil (1992) found that a neoclassical growth model that includes human capital provides an excellent explanation cross-country economic growth, far superior to the basic model sketched out above. The production function can be modified to include the stock of human capital, H_t:

(17) $$Y_t = A_t K_t^{\alpha} H_\tau^{\beta} L_t^{1-\alpha-\beta}.$$

Let *h* be the fraction of income invested in human capital. Then, per capita income growth between year 0 and year t is given by

(18) $$\log y_t - \log y_0 = (1 - e^{-\lambda t})(a + \alpha/(1- \alpha-\beta) \log s + \beta/(1- \alpha-\beta) \log h - (\alpha+\beta)/(1- \alpha-\beta) \log (n + g + \delta) + \varepsilon) - (1 - e^{-\lambda t}) \log y_0.$$

The third and fourth columns of Table 1 add a proxy for the rate of accumulation of human capital to the right-hand side regressors of equation (16).[5] The variable HIGH SCHOOL is the proportion of the county population of persons 25 years and over who were high school graduates or higher. The data for 1970, 1980, and 1990, obtained from various editions of the *County and City Data Book*, were averaged to compute HIGH SCHOOL. Log (HIGH SCHOOL) does little to improve the fit of the equation. None of the independent variables is significant.

The variable COLLEGE is the average proportion of the county population of persons 25 years and over who have a bachelor's degree or higher for the years 1970, 1980, and 1990. In this regression, the coefficient of rate of human capital accumulation is positive and significantly different from zero with a p-value of 0.0002. Population growth has the expected sign and is significant at the 10 percent level. The savings variable now has a negative coefficient, but it is not statistically significant. Most striking, initial year income has a negative coefficient with a p-value of 0.006. The adjusted R-squared of the regression is 0.22. Here we have evidence of convergence of income across Pennsylvania counties. The implied speed of convergence is 0.0126 or about 1.3 percent a year.

Figure 2 presents a graphical demonstration of the conditional convergence of personal income across Pennsylvania counties. The logs of the investment rate, $(n + g + \delta)$, and the average of the proportion of the county population of persons 25 years and over who have a bachelor's degree or higher are partialed out of the growth rate variable to yield each county's conditional growth rate of personal income. The figure plots this conditional growth rate against the log of personal income per capita in 1969. The tendency toward convergence is clear.

Table 2 presents an estimate of equation (16) containing log (COLLEGE) with the restriction that the coefficients on log *s*, log *h*, and log $(n + g + \delta)$ sum to zero. The restriction is not rejected at conventional levels of significance and has little effect on the coefficients. The implied speed of convergence is derived from the coefficient on log y_{1969}. The value of 0.012 indicates that the economy of the typical Pennsylvania county moves halfway to its steady-state in about 60 years. The implied value of α, the share of income going to physical capital, 0.01, is far, far below the anticipated value of one third. The estimate of β from Table 2 is more reasonable. β is the share of income going to human capital, and Mankiw, Romer, and Weil (1992, p. 417) suggest that β ought to be between one third and one half. The estimated β is 0.38.

CONCLUSIONS

The neoclassical growth model implies that if two economies have the same preferences and technology, the poorer economy will tend to grow faster in per capita terms. The relatively homogenous counties of Pennsylvania provide an excellent test of the neoclassical growth model's prediction of convergence in living standards. The counties possess identical access to technology and have similar cultural and political institutions; the preferences of a representative Luzerne County household are going to be closer to the preferences of a Lehigh County resident than to those of a representative English household. Surprisingly, this paper found no evidence of unconditional convergence. The addition of savings and population growth variables did nothing to rescue the neoclassical model.

Convergence is uncovered when the rate of human capital accumulation is added to the income growth model. An estimation of the model using the proportion of the county population of persons 25 years and over who have a bachelor's degree or higher provides a decent fit. The coefficient of the log of initial year income is negative and significantly different from zero. In the restricted regression, the 95 percent confidence interval for the coefficient estimate is –0.44 to –0.08. Pennsylvania counties move halfway to their economic steady-state in between 30 and 210 years.

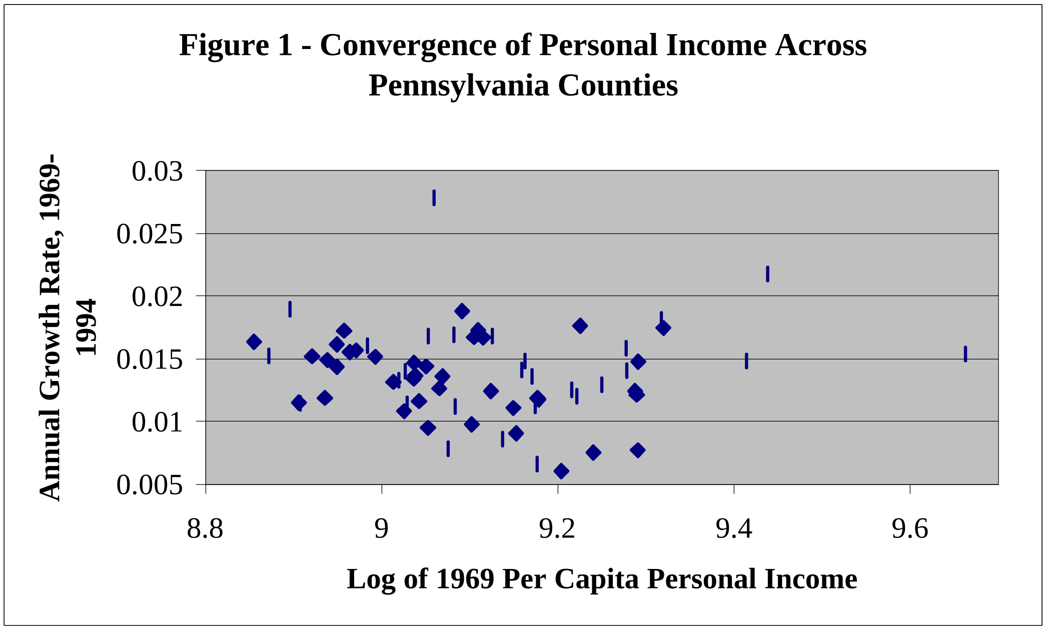
Figure 1 - Convergence of Personal Income Across Pennsylvania Counties
Annual Growth Rate, 1969-1994
0.03
0.025
0.02
0.015
0.01
0.005
8.8
9
9.2
9.4
9.6
Log of 1969 Per Capita Personal Income

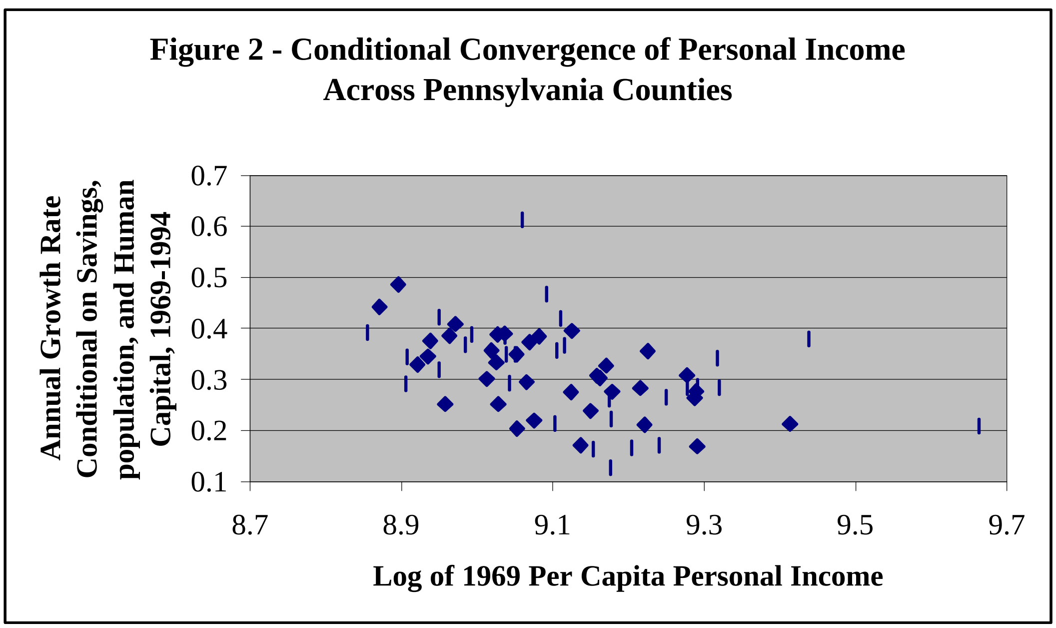
Figure 2 - Conditional Convergence of Personal Income Across Pennsylvania Counties
Annual Growth Rate Conditional on Savings, population, and Human Capital, 1969-1994
0.7
0.6
0.5
0.4
0.3
0.2
0.1
8.7
8.9
9.1
9.3
9.5
9.7
Log of 1969 Per Capita Personal Income

Table 1
Tests for Convergence

Dependent variable: log difference personal income per capita 1969-1994

	Unconditional	Conditional on *s* and $(n + g + \delta)$	Conditional on *s*, $(n + g + \delta)$, and HIGH SCHOOL	Conditional on *s*, $(n + g + \delta)$, and COLLEGE
CONSTANT	0.594	0.470	0.923	2.784
	(0.881)	(0.540)	(0.934)	(2.862)
Log y_{1969}	-0.027	-0.029	-0.073	-0.271
	(0.370)	(0.348)	(0.777)	(2.837)
Log *s*		0.003	0.002	-0.002
		(0.231)	(0.114)	(0.126)
Log $(n + g + \delta)$		-0.051	-0.059	-0.134
		(0.623)	(0.718)	(1.757)
Log HIGH SCHOOL			0.161	
			(0.967)	
Log COLLEGE				0.159
				(3.994)
Adjusted R^2	-0.01	-0.04	-0.04	0.22
standard error	0.09	0.09	0.09	0.08
Observations	66	66	66	66
Implied λ	0.0011	0.0012	0.0030	0.0126

Note: Absolute values of t-statistics are in parentheses. Y_{1969} is personal income per capita in 1969. The savings and population growth rates are averages for the period 1969-1994. $(g + \delta)$ is assumed to equal 0.05. HIGH SCHOOL is the average proportion of the county population of persons 25 years and over who were high school graduates or higher for the period 1969-1994. COLLEGE is an average of the proportion of the county population of persons 25 years and over who have a bachelor's degree or higher for the period 1969-1994.

Table 2
Test for Conditional Convergence, Restricted Regression

Dependent variable: log difference personal income per capita 1969-1994

	Conditional on *s*, ($n + g + \delta$), and COLLEGE
CONSTANT	2.625
	(3.314)
Log y_{1969}	-0.261
	(2.956)
Log *s* – Log ($n + g + \delta$)	-0.004
	(0.311)
Log COLLEGE - Log ($n + g + \delta$)	0.157
	(4.058)
Adjusted R^2	0.18
standard error	0.08
Observations	66
p-value of test of restriction	> 0.99
Implied λ	0.0121
Implied α	0.01
Implied β	0.38

Note: Absolute values of t-statistics are in parentheses. Y_{1969} is personal income per capita in 1969. The savings and population growth rates are averages for the period 1969-1994. ($g + \delta$) is assumed to equal 0.05. COLLEGE is an average of the proportion of the county population of persons 25 years and over who have a bachelor's degree or higher for the period 1969-1994.

ENDNOTES

1. http://www.bea.doc.gov/remd/BF8494/42/index.htm

2. Mankiw, Romer, and Weil (1992, pp. 413-414) state that δ is 0.03 for the U.S. and that g is about 0.02.

3. If the level of income influences s, n, and the human capital variables introduced below, then estimates of equation (15) using OLS are potentially inconsistent. If they can be found, instrumental variables that are correlated with s, n, and the human capital variable but uncorrelated with the county-specific shocks would remedy the problem.

4. In 1969, the standard deviation of the log of personal income per capita across Pennsylvania counties was 0.15; in 1994, it was 0.17. Barro and Sala-I-Martin (1995, p. 383) call this σ-divergence.

5. As long as the proxy for the rate of human capital accumulation is proportional to the actual rate, then estimates of β obtained by regressing equation (18) will be unbiased estimates of the actual β.

REFERENCES

Barro, Robert J. and Xavier Sala-i-Martin. 1992. Convergence. Journal of Political Economy. 100, April 1992: 223-251.

Barro, Robert J. and Xavier Sala-i-Martin. 1995. Economic Growth. New York: McGraw-Hill.

Dowrick, Steve, and Duc-Tho Nguyen. 1989. OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence. American Economic Review. 79, December 1989: 1010-1030.

Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics. 107, May 1992: 407-437.

Romer, Paul M. 1994. The Origins of Endogenous Growth. Journal of Economic Perspectives. 8, Summer 1994: 3-22.

U.S. Department of Commerce, Bureau of Economic Analysis. 1994. Local Area Personal Income, 1969-92. Washington, DC: U.S. Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1996. 1992 Census of Manufactures. Washington, DC: U.S. Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. various years. City and County Data Book. Washington, DC: U.S. Government Printing Office.